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DEVICE FOR PRODUCING TUBULAR PREFORMS
WITH AN ASYMMETRICAL ANNULAR PISTON

The invention concerns devices for producing multilayer, coextruded, tubular preforms made of thermoplastic material. A device of this type has a coextrusion head with several, essentially coaxially arranged, flow channels, each of which is fed from an individual inlet opening with a material melt, which is annularly distributed and flows along an annular conical frustum, wherein the flow channels become a common annular flow channel that widens like a funnel. A displaceable annular piston can reciprocate in an annular accumulation chamber, which is followed by an annular discharge channel with an annular extrusion orifice that can be closed.

EP 0 326 584 B1 of the same applicant discloses a method and a device for producing large-volume hollow plastic bodies with multilayer walls. The gap widths in each flow channel are constant along the circumference of the ring. Due to the one-sided supply of the material melt, different pressure conditions thus develop along the ring and along the annular conical

frustum, which impair uniform flow of the material melt, so that material mixing occurs, which leads to loss of quality of the preform.

In addition, DE 195 45 441 A1 of the same applicant discloses a device for producing dish-shaped molded parts made of a thermoplastic material. This device also uses a coextrusion head, in which the material melt flows in several layers, from which a multilayer tubular preform is produced.

The present invention builds on the prior art disclosed in the two documents cited above. The content of these documents is herewith incorporated in the disclosed content of the present application.

The objective of the invention is to specify a device of the aforementioned type, in which uniform flow of the multilayer material melt in the coextrusion head is realized.

A further objective of the invention is to specify a device with a simple feed device for supplying the material melt.

Yet another objective of the invention is to specify a device, in which the annular accumulation chamber is filled with material melt gently and with a high degree of uniformity.

These objectives are achieved by the objects specified in the claims. Advantageous refinements are specified in the dependent claims.

The invention is explained below with reference to specific embodiments.

-- Figure 1 shows a longitudinal section through a coextrusion head.

-- Figure 2 shows a cross section through the first distributor ring.

-- Figure 3 shows a cross section through the first flow channel.

-- Figure 4 shows a cross section through the second distributor ring.

-- Figure 5 shows a cross section through the second flow channel.

-- Figure 6 shows a cutaway section to show the gap widths.

-- Figure 7 shows a longitudinal section through the coextrusion head with baffle and load-relieving cylinder.

-- Figure 8 shows a longitudinal section through the coextrusion head with a first feeding device.

-- Figure 9 shows a longitudinal section through a second feeding device.

Figure 1 shows a partial longitudinal section of a coextrusion head 10, which comprises an accumulator jacket 8, which surrounds an annular accumulation chamber 14, which holds the material melt to be discharged. The accumulator jacket 8 is connected with a housing (not shown). A first material melt is fed through an inlet opening ZF1 to a first distributor ring 26, which is part of an annular piston 16. The annular piston 16 can be moved along its longitudinal axis and slides along a torpedo 6 and the accumulator jacket 8. The annular piston 16 is connected by piston rods K1, K2 with a hydraulic system (not shown). The torpedo 6 is likewise connected at its upper end with a hydraulic system (not shown).

The first material melt is conveyed horizontally along the first distributor ring 26 and at the same time flows downward along an annular flow channel FK1, which is designed as an annular conical frustum. The downward flowing first material melt then enters a first cylindrical ring 22 and from there reaches a orifice_30, into which a second material melt opens. This second material melt is supplied through a second inlet opening ZF2, which is arranged diametrically to inlet opening ZF1. The second material melt is likewise distributed from the second inlet opening ZF2 by an associated peripheral second

distributor ring 28 and enters the second flow channel FK2, which is designed as an annular conical frustum. The second material melt flows from there into a second cylindrical ring 24, from which it reaches the orifice 30.

The two material melts should flow in such a way that the interface between the two material melts runs as smoothly as possible and is not disturbed by turbulence. The orifice 30 is followed by a region of quieted flow, which is formed as a common cylindrical ring 34. This region of quieted flow ensures that after the material melts come together at the orifice 30, uniform flow of the material melts is obtained, so that smooth running of the interface between the two material melts is produced. The two material melts then flow to a point of widening 32, where they enter a widening, common flow channel 12. This flow channel 12 has a funnel-shaped cross section and is annularly formed in the annular piston 16.

At the beginning of the filling operation, the annular piston 16 is in its lower position, as is schematically indicated by broken lines in connection with reference number 15. The funnel-shaped common channel 12 is still filled with the two material melts from the previous production operation for producing a tubular preform. The resumption of flow of the

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two material melts causes the annular piston 16 to move upward. Due to the funnel shape of the common flow channel 12 and the other geometry of the material melt supply system, the interface that forms between the two material melts remains largely smooth and is not swirled into a turbulent state.

When the annular piston 16 has reached its upper operating point, the torpedo 6 is moved downward, and its nozzle pintle 6a opens an annular extrusion orifice 20, so that during a downward movement of the annular piston 16, the tubular preform with the interface between the two material melts is discharged. To maintain smooth running of the interface, an annular discharge channel 18 is provided with a special geometry. When the discharge operation has been completed, the torpedo 6 is moved back up and closes the extrusion orifice 20, whereupon a new filling operation for the annular accumulation chamber 14 begins.

The geometric features of the design of the annular piston 16 that are responsible for the uniform flow of the material melt that is supplied are explained below. As Figure 1 shows, the first distributor ring 26 is not formed symmetrically with respect to the center axis m, but rather it has a greater cross-sectional area in the vicinity of the first inlet opening ZF1

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than it does on the opposite side from the inlet opening ZF1. This is illustrated in Figure 2 by a cross section along line A-A. The gap width s_1 of the first distributor ring 26 is greater in the vicinity of the first inlet opening ZF1 than the gap width s_2 on the opposite side. The material melt flows from this distributor ring 26 into the annular flow channel FK1. Figure 3 shows a cross section through this flow channel along line B-B. The effective gap width s_3 , i.e., the gap width in the direction of the normal, approximately in the center of the annular conical frustum, is smaller on the side of the first inlet opening ZF1 than the gap width s_4 on the opposite side. The annular cross-sectional area F_{26} in the center of the first distributor ring 26 along the sectional line AA is greater than the mean effective cross-sectional area F_{FK1} of the first flow channel FK1 along the sectional line BB. Accordingly, the material melt flow is throttled, and there is an increase in pressure.

Figures 4 and 5 show the conditions with respect to the second material melt. The gap width s_5 of the second distributor ring 28 is greater on the side of the second inlet opening ZF2 than the gap width s_6 on the opposite side. In the second flow channel FK2, the gap width s_7 on the side of the

second inlet opening ZF2 is smaller than the gap width s8 on the opposite side. Here again, there is an increase in pressure when the material melt flows from the inlet opening ZF2 into the second flow channel FK2, since the annular cross-sectional area F28 is greater than the cross-sectional area FFK2 of the second flow channel FK2.

After passing through the first flow channel FK1, the first material melt enters the first cylindrical ring 22 (see Figure 1). This cylindrical ring 22 has a constant gap width s9 along its length and circumference. This gap width s9 is configured in such a way that the cross-sectional area F22 of the cylindrical ring 22 is greater than the cross-sectional area FFK1 at the end of the first flow channel FK1, which makes a transition into the cylindrical ring 22. F22 is preferably twice as large as FFK1. Similar conditions apply to the second material melt, which flows from the second flow channel FK2 into the cylindrical ring 24. This cylindrical ring 24 has a constant gap width s10, which is configured in such a way that the cross-sectional area F24 is greater than the cross-sectional area FFK2 at the end of the second flow channel FK2. The specified geometric configuration and the resulting asymmetrical guidance and throttling of the flow of the material melt provide

uniform flow from the distributor rings 26 and 28 via the flow channels FK1 and FK2, which are shaped like conical frustums, to the cylindrical rings 22 and 24.

Figure 6 shows the geometric relationships on the basis of a cutaway section with distributor ring 26, flow channel FK1, and cylindrical ring 22, and the associated size relationships for the gap widths s_1 , s_3 , and s_9 and the annular cross-sectional areas F_{26} , F_{FK1} , and F_{22} . The first material melt flowing in at ZF1 is uniformly distributed in the horizontal direction along the distributor ring 26 and does not flow off immediately in the vertical direction into the first flow channel FK1, since the latter has a reduced gap width $s_3 < s_4$ in the vicinity of the inlet opening ZF1, and $F_{26} > F_{FK1}$. Since $s_4 > s_3$, the flow rate at s_3 is greater than at s_4 at otherwise equal material volume/time. In the cylindrical ring 22 with $s_9 > s_3$, the material is quieted, and the material flow rate is equalized in the circumferential direction of the cylindrical ring 22, with the result that the first material melt has the same flow rate along the circumference at the orifice 30.

The dimensions of the gap widths s_1 to s_{10} are to be selected as a function of the material for the first material melt and the second material melt. Typically, the cross-

sectional areas F_{22} and F_{24} of the cylindrical rings 22 and 24 can be selected to be at most half as great as the cross-sectional areas F_{26} and F_{28} of the corresponding distributor rings 26 and 28.

The two material melts meet at the orifice 30 and pass together through the common cylindrical ring 34, which likewise constitutes a region of quieted flow in which turbulence of the interface between the two material melts is avoided. The cross-sectional area F_{34} of this common cylindrical ring 34 is equal to the sum of the cross-sectional areas F_{22} and F_{24} of the cylindrical rings 22 and 24 ($F_{34} = F_{22} + F_{24}$). The length L_{34} of the common cylindrical ring 34 is preferably greater than or equal to twice the sum of the gap widths of cylindrical ring 22 and cylindrical ring 24 ($L_{34} \geq 2(s_9 + s_{10})$).

After passing through the region of quieted flow and the point of widening 32, the united material melts enter the common flow channel 12, which widens like a funnel. This flow channel 12 is bounded by an inner conical frustum surface 36 and an outer conical frustum surface 38. When viewed in longitudinal section, these conical frustum surfaces 36, 38 form an asymmetrical funnel, with a first angle between the vertical and the inner conical frustum surface 36 being smaller than a second

angle between the vertical and the outer conical frustum surface 38. The first angle can typically be on the order of 0° , i.e., the inner conical frustum surface 36 can be configured as a cylindrical surface.

Figure 7 shows an example in which the material flow within the first flow channel FK1 is controlled by throttling with a baffle. The flow channel FK1 is configured as an annular conical frustum and is bounded by an outer wall 40 and an inner wall 41. An annular groove 42 that holds the baffle 44 is set in the outer wall 40. This baffle 44 can be moved into the corresponding annular conical frustum for throttling the flow of the material melt in the flow channel FK1. Preferably, an elastic baffle 44 is used, whose inside diameter can be varied by means of an adjusting device. Reduction of this inside diameter then produces throttling of the material flow. Figure 7 shows only a baffle 44 for the first flow channel FK1. It is also possible to install a throttling device of this type in only one of the two flow channels FK1 or FK2, or in both of these flow channels and in other flow channels.

Figures 8 and 9 show embodiments in which a special feeding device is used to supply the material melt. In Figure 8, the first inlet opening ZF1 is connected with a feeding device 50,

which in turn is rigidly connected with the housing of the coextrusion head 10, for example, seated in a stationary manner on the accumulator jacket 8, supported by a column 57. As was mentioned earlier, the annular piston 16 can move up and down. The feeding device 50 contains a recess 54, which further conveys the material melt to the inlet opening ZF1 during the stroke of the annular piston 16. The recess 54 receives the material melt via an inlet channel 55, which is rigidly connected with an extruder line (not shown). A similar feeding device 52 with a recess 56 is also provided for the second material melt, which is supplied to the second inlet opening ZF2. The recesses 54, 56 have a vertical length equal to the stroke of the annular piston 16. The feeding device 50, 52 is preferably designed as an annular segment and extends along the circumference of the annular piston 16. In this example, the extruder line does not have to perform any rotating movements during the stroke of the annular piston 16, so that it is possible to save moving parts. The columns 57 hold the feeding devices 50, 52 and leave sufficient free space around the feeding device 50, 52, so that adequate material, which then becomes encrusted, can be easily removed from the region of the recesses 54, 56.

Figure 9 shows an alternative solution for the feeding. The inlet opening ZF1 is rigidly connected with a feed cylinder 60. The feed cylinder 60 thus carries out the lifting movement of the annular piston 16. A hollow feed piston 62 moves in the feed cylinder 60. The hollow feed piston 62 is connected in a stationary manner, for example, rigidly, with the jacket ring 8. The feed piston 62 is also rigidly connected with an extruder line 64, which supplies the material melt. In this arrangement as well, the extruder line 64 does not have to carry out any tilting or rotating movement corresponding to the movement of the inlet opening ZF1. A similar feeding device can also be provided for the second inlet opening ZF2.

Figure 7 shows another example, in which the annular piston 16 is rigidly connected with a hydraulic system 70, which is acted upon with hydraulic fluid through a hydraulic line 72. The hydraulic system 70 serves the purpose of load relief and works in such a way that it takes some of the weight of the annular piston 16, which weighs on the melt in the annular accumulation chamber 14 as the latter is being filled. The annular piston 16 can weigh several tons, and the material properties of the material melt can change under this pressure. The hydraulic system 70 thus removes some of the weight during

the filling of the annular accumulation chamber 14. When the material melt is discharged from the annular accumulation chamber 14 through the annular extrusion orifice 20, the hydraulic system is switched to an inoperative status, so that the weight of the annular piston 16 assists with the discharge. It is advantageous for the hydraulic system 70 to have a cylinder 74 with a piston 76, with the cylinder 74 being rigidly connected with the annular piston 16. The piston 76 is supported on the housing or the annular jacket 8, which results in a compact configuration. It is advantageous for two units consisting of a cylinder and piston to be installed on diametrically opposite sides of the annular piston 16.

In accordance with an additional measure, a collecting device 80 is installed above the annular piston 16 for collecting hydraulic oil dripping from the hydraulic systems for the annular piston 16 and the torpedo 6. This hydraulic oil would drip from the top end of the annular piston 16, which is hot during operation, and cause fouling and other problems. The hydraulic oil is carried away from the vicinity of the annular piston 16 by a drain line 82 and removed.

The examples shown here concern a coextrusion head for processing two material melts. If more than two material melts

are to be processed, correspondingly greater numbers of inlet openings, distributor rings, flow channels, etc., must be provided in similar fashion. In practice, it is possible to process five or even six different material melts, which results in a complex design of the annular piston 16 and other associated structural parts.

List of Reference Numbers

6	torpedo
8	accumulator jacket
10	coextrusion head
12	common flow channel
14	annular accumulation chamber
ZF1	first inlet opening
ZF2	second inlet opening
16	annular piston
K1, K2	piston rods
15	lower position of the annular piston
18	annular discharge channel
20	extrusion orifice
22	first cylindrical ring
24	second cylindrical ring
26	first distributor ring
28	second distributor ring
30	orifice
32	point of widening
34	common cylindrical ring

s1 to s10	gap widths
F26	cross-sectional area of the first distributor ring
F28	cross-sectional area of the second distributor ring
FK1	first flow channel
FK2	second flow channel
FFK1	cross-sectional area of the first flow channel
FFK2	cross-sectional area of the second flow channel
F22	cross sectional area of the first cylindrical ring
F24	cross-sectional area of the second cylindrical ring
F34	cross-sectional area of the common cylindrical ring
L34	length
36	inner conical frustum surface
38	outer conical frustum surface
40	outer wall
41	inner wall
42	groove
44	baffle
50, 52	feeding device
54, 56	recess

55	inlet channel
57	columns
60	feed cylinder
62	feed piston
64	extruder line
70	hydraulic system
72	hydraulic line
74	cylinder
76	piston
80	collecting device
82	drain line

CLAIMS

1. Device for producing multilayer, coextruded, tubular preforms made of thermoplastic material, with a coextrusion head (10) with several essentially coaxially arranged flow channels (FK1, FK2), each of which is fed from an individual inlet opening (ZF1, ZF2) with a material melt, which is annularly distributed in a distributor ring (26, 28) and flows along an annular conical frustum, wherein the material melts flow into a common annular flow channel (12) that widens like a funnel, with an annular accumulation chamber (14), in which a displaceable annular piston (16) can reciprocate, and with an annular discharge channel (18) that follows the annular accumulation chamber (14) and has an annular extrusion orifice (20) that can be closed, characterized by the fact that, as viewed in a longitudinal section through the coextrusion head, the gap width (s1, s5) in the respective distributor ring (26, 28) is greater in the vicinity of the inlet opening (ZF1, ZF2) than the gap width (s2, s6) on the opposite side from the inlet opening (ZF1, ZF2), and that, as viewed in a longitudinal section through the coextrusion head, the gap width (s3, s7) in the respective flow channel (FK1, FK2) is smaller in the vicinity of the inlet opening (ZF1, ZF2) than the gap width (s4, s8) on the opposite

side from the inlet opening (ZF1, ZF2).

2. Device in accordance with Claim 1, wherein the mean cross-sectional area (F26, F28) of the respective distributor ring (26, 28) is greater than a mean effective cross-sectional area (FFK1, FFK2) of the corresponding flow channel (FK1, FK2).

3. Device in accordance with either of the preceding claims, wherein each flow channel (FK1, FK2) opens into a first cylindrical ring (22, 24), and wherein the cross-sectional area (F22, F24) of the respective cylindrical ring (22, 24) is greater, preferably twice as great, as the cross-sectional area (FFK1, FFK2) at the end of the corresponding flow channel (FK1, FK2).

4. Device in accordance with Claim 3, wherein the cross-sectional area (F22, F24) of the respective cylindrical ring (22; 24) is at most twice* as great as the mean cross-sectional area (F26, F28) of the corresponding distributor ring (26; 28).

5. Device in accordance with any of the preceding claims, wherein a region of quieted flow, which is formed as a common cylindrical ring (34), is provided between the mouth (30), at which several* material melts come together, and the point of widening (32), at which the combined material melts enter the common flow channel (12), which widens like a funnel.

6. Device in accordance with Claim 5, wherein the cross-sectional area (F34) of the common cylindrical ring (34) is equal to the sum of the cross-sectional areas (F22, F24) of the first [sic - Only 22 is the first cylindrical ring; 24 is the second cylindrical ring; therefore "first" should read "first and second."] cylindrical rings (22, 24).

7. Device in accordance with Claim 6, wherein the length [L34] of the common cylindrical ring (34) is greater than or equal to twice the sum of the annular gaps (s9, s10) of the corresponding cylindrical rings (22, 24).

8. Device in accordance with any of the preceding Claims 1 to 7, wherein the funnel-shaped, annular common flow channel (12) is bounded by an inner conical frustum surface (36) and an outer conical frustum surface (38), such that when viewed in a longitudinal section through the coextrusion head (10), a first angle between the vertical and the inner conical frustum surface (36) is smaller than a second angle between the vertical and the outer conical frustum surface (38).

9. Device in accordance with Claim 8, wherein the first angle is about 0° .

10. Device in accordance with Claim 9, wherein the inner surface [36] is configured as a cylindrical surface.

11. Device in accordance with any of Claims 1 to 10, wherein an annular groove (42) is provided in an outer wall (40) in the vicinity of each flow channel (FK1, FK2), which is configured as an annular conical frustum, and the annular groove holds a baffle (44), which can be moved into the annular conical frustum to throttle the flow of the material melt.

12. Device in accordance with Claim 11, wherein the inside diameter of the elastic baffle (44) can be varied by means of an adjusting device.

13. Device in accordance with any of Claims 1 to 12, wherein each inlet opening (ZF1, ZF2) is connected with a feeding device (50, 52), which is rigidly connected with the coextrusion head (10) and has a feed recess (54, 56), which further conveys the material melt to the inlet opening (ZF1, ZF2) during the stroke of the annular piston (16), and wherein the material melt is supplied to the feeding device (50, 52) through a rigidly connected extruder line.

14. Device in accordance with Claim 13, wherein the feed recess (54, 56) has a length equal to the stroke of the annular piston (16).

15. Device in accordance with Claim 14, wherein the feeding device (50, 52) is designed as an annular segment.

16. Device in accordance with any of the preceding Claims 13 to 15, wherein two feeding devices (50, 52) arranged diametrically to each other are provided for two different material melts.

17. Device in accordance with any of the preceding Claims 1 to 12, wherein each inlet opening (ZF1, ZF2) is connected with a feed cylinder (60), which is rigidly mounted on the displaceable annular piston (16) and holds a movable hollow feed piston (62), which is mounted in a stationary way and to which the material melt is supplied by an extruder line (64) that is rigidly connected with it.

18. Device in accordance with any of the preceding Claims 1 to 17, wherein the displaceable annular piston (16) is connected with a hydraulic system (70), which takes some of the weight of the annular piston (16) during the filling of the annular accumulation chamber (14) with the material melt.

19. Device in accordance with Claim 18, wherein means are provided which allow the hydraulic system (70) to be switched to an inoperative status while the material melt is being discharged from the annular accumulation chamber (14).

20. Device in accordance with Claim 18 or 19, wherein the hydraulic system (70) has at least one cylinder (74) with a

piston (76), with the cylinder (74) being rigidly connected with the annular piston (16), and with the piston (76) being supported on the housing (8) that encloses the annular accumulation chamber (14).

21. Device in accordance with Claim 20, wherein two units consisting of a cylinder (74) and piston (76) are installed on diametrically opposite sides of the annular piston (16).

22. Device in accordance with any of Claims 1 to 21, wherein a collecting device (80) is installed above the annular piston (16) for collecting hydraulic oil from the hydraulic system for the annular piston (16) and/or from the hydraulic system for the torpedo (6).